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(57) [Abstract]

[Purpose] To provide a power source device with high input efficiency, low input current waveform distortion and very little rise in voltage under a light load that is able to supply smoothed direct current power to a high-frequency conversion device.

[Constitution] An auxiliary direct current power source 6 is installed on the input side of the high-frequency conversion device 1 for supplying voltage to a high-frequency conversion device 1 instead of a rectifying device 100 during the trough portion of the output voltage period for the rectifying device 100 so that the current flows from the rectifying device 100 via an inductor 12 during the voltage supply period from the auxiliary direct current power source 6 to the high-frequency conversion device 1. The power is stored in the inductor 12, and the stored power is used to charge a first capacitor with relatively small capacitance acting on the high frequency.

[Effect] The rectifying device input current flows continuously during nearly the entire period of the various half-cycles of the alternating current voltage waveform, and the waveform approximates a sine wave. This can smooth the supply of current to the high-frequency current device, improve input efficiency, and reduce the high-frequency component contained in the inputted current. Because the trough portion of the pulsating voltage is filled in, the rise in voltage during a light load is small.

[Claims]

[Claim 1] A power source device comprising a rectifying device for rectifying alternating current power source voltage, a high-frequency conversion device for converting the voltage outputted from the rectifying device to high-frequency voltage consisting of at least one switching device for switching the voltage outputted from the rectifying device using a high-frequency, an auxiliary direct current power source installed on the input end of the high-frequency conversion device with an output voltage value smaller than the peak value of the output voltage from the rectifying device, an inductor installed in series with the switching device of the high-frequency conversion device between the output terminals of the rectifying device to store power using the current supplied from the rectifying device when the switching device is turned on, and a first capacitor installed in parallel with the auxiliary direct current power source on the input end of the high-frequency conversion device for charging the charge voltage of the inductor when the switching device in the high-frequency conversion device is turned on and with a relatively small capacitance for acting in a high-frequency manner to supply the stored charge to the high-frequency conversion device when the switching device is turned on.

[Claim 2] A power source device comprising a rectifying device for rectifying alternating current power source voltage, a high-frequency conversion device for converting the voltage outputted from the rectifying device to high-frequency voltage consisting of at least one switching device for switching the voltage outputted from the rectifying device using a high-frequency, a rectifying element installed in at least one of the output terminals of the rectifying device with the same polarity as the output from the rectifying device, an auxiliary direct current power source installed on the input end of the high-frequency conversion device via the rectifying element with an output voltage value smaller than the peak value of the output voltage from the rectifying device, an inductor installed in series with the switching device of the high-frequency conversion device between the output terminals of the rectifying device to store power using the current supplied from the rectifying device when the switching device is turned on, and a first capacitor installed in parallel with the auxiliary direct current power source on the input end of the high-frequency conversion device for charging the charge voltage of the inductor when the switching device in the high-frequency conversion device is turned on and with a relatively small capacitance for acting in a high-frequency manner to supply the stored charge to the high-frequency conversion device when the switching device is turned on.

[Claim 3] A power source device comprising a rectifying device for rectifying alternating current power source voltage, a high-frequency conversion device for converting the voltage outputted from the rectifying device to high-frequency voltage consisting of a pair of switching devices for switching the voltage outputted from the rectifying device using a high-frequency, an auxiliary direct current power source installed on the input end of the high-frequency conversion device with an output voltage value smaller than the peak value of the output voltage from the rectifying device, an inductor installed in series with one of

the switching devices of the high-frequency conversion device between the output terminals of the rectifying device to store power using the current supplied from the rectifying device when the switching device is turned on, a first capacitor installed in parallel with the auxiliary direct current power source on the input end of the high-frequency conversion device for charging the charge voltage of the inductor when the switching device in the high-frequency conversion device is turned on and with a relatively small capacitance for acting in a high-frequency manner to supply the stored charge to the high-frequency conversion device when the switching device is turned on, and a control means for changing the switching frequency of the pair of switching devices for the high-frequency conversion means and changing the output from the inverter as well as for making the on period of the switching device installed in series with the inductor longer than the other switching device when the switching frequency has been changed to be relatively high.

[Claim 4] A power source device comprising a rectifying device for rectifying alternating current power source voltage, a high-frequency conversion device for converting the voltage outputted from the rectifying device to high-frequency voltage consisting of a pair of switching devices for switching the voltage outputted from the rectifying device using a high-frequency, a rectifying element installed in at least one of the output terminals of the rectifying device with the same polarity as the output from the rectifying device, an auxiliary direct current power source installed on the input end of the high-frequency conversion device via the rectifying element with an output voltage value smaller than the peak value of the output voltage from the rectifying device, an inductor installed in series with one of the switching devices of the high-frequency conversion device between the output terminals of the rectifying device to store power using the current supplied from the rectifying device when the switching device is turned on, a first capacitor installed in parallel with the auxiliary direct current power source on the input end of the high-frequency conversion device for charging the charge voltage of the inductor when the switching device in the high-frequency conversion device is turned on and with a relatively small capacitance for acting in a high-frequency manner to supply the stored charge to the high-frequency conversion device when the switching device is turned on, and a control means for changing the switching frequency of the pair of switching devices for the high-frequency conversion means and changing the output from the inverter as well as for making the on period of the switching device installed in series with the inductor longer than the other switching device when the switching frequency has been changed to be relatively high.

[Claim 5] The power source device of any one of claims 1 through 4, wherein a high-frequency rejection filter is installed between the alternating current power source and the rectifying device.

[Claim 6] The power source device in any one of claims 1 through 5, wherein the auxiliary direct current power source has a charging portion connected via the switching device of the high-frequency conversion device between the terminals of the second capacitor with a relatively large capacitance and the first capacitor including a current-limiting inductor in series for charging the second capacitor with the output from the first capacitor when the switching device is turned on, and a discharging portion connected in series to the second capacitor and installed between the input terminals of the second capacitor and the high-frequency conversion device to form a discharge route for the second capacitor via the high-frequency conversion device.

[Claim 7] The power source device of claim 6, wherein the switching device of the high-frequency conversion device, the current-limiting inductor and the second capacitor constitute a chopper by charging the current-limiting device with power using current supplied via the switching device of the high-frequency conversion device when the

switching device of the high-frequency conversion device is turned on, and by supplying the charged power in the current-limiting inductor device to the second capacitor of the auxiliary direct current power source via the components of the high-frequency conversion device when the switching device of the high-frequency conversion device is turned off.

[Claim 8] The power source device of any one of claims 1 through 5, wherein the auxiliary direct current power source has a third capacitor with a relatively large capacitance charged by either some of the rectified voltage outputted from the high-frequency conversion device or some of the step-down rectified alternating current power source voltage outputted from the rectifying device, and a discharging portion connected in series to the third capacitor and installed between the input terminals of the third capacitor and the high-frequency conversion device to form a discharge route for the third capacitor via the high-frequency conversion device.

[Claim 9] The power source device of any one of claims 1 through 8, wherein a protective means is installed to turn off or reduce the on duty of the switching device in the high-frequency conversion device when a signal corresponding to the voltage value of the auxiliary direct current power supply exceeds a predetermined value.

[Claim 10] A discharge lamp lighting device comprising a discharge lamp and the power source device in any one of claims 1 through 9 for lighting this discharge lamp.

[Claim 11] A lighting device comprising a lighting device main unit, a discharge lamp installed in this lighting device main unit, and the power source device in any one of claims 1 through 10 for lighting this discharge lamp.

[Detailed Description of the Invention]

[0001] [Purpose of the Invention]

[0002]

[Field of Industrial Application] The present invention relates to a power source device, a discharge lamp lighting device and a lighting device using this discharge lamp lighting device in which alternating current voltage is rectified and high-frequency voltage is generated from the rectified direct current voltage.

[0003]

[Prior Art] A proposed power source device for generating high-frequency voltage from direct current voltage is shown in FIG 21. Here, e is the alternating current power source, 100 is a rectifying device, and 110 is the inverter serving as the high-frequency conversion device for converting the voltage outputted from the rectifying device 100 to high-frequency voltage. The inverter 110 in FIG 21 has a parallel resonance circuit 111 and a field-effect transistor serving as a switching device 112. 120 is the fluorescent lamp serving as the load. A capacitor 121 for starting the lamp is connected between the terminals on the non-power source side with various filaments. 200 is an auxiliary direct current power source for supplying direct current voltage to the inverter 110 instead of the rectifying device 110 during the trough portion of the timing in which the instantaneous value of the voltage outputted from the rectifying device 110 is lower than a predetermined value. In FIG 21, a capacitor 201, an inductor serving as a current-limiting impedance device 202, and series circuit with an isolating diode 203 are connected between the input terminals of the inverter 110, and a backflow-preventing diode 204 is installed between the midway point of the

parallel resonance circuit 111 of the inverter 110 and the switching device 112 and the midway point of the current-limiting impedance device 202 and the isolating diode 203.

[0004] The following is an explanation of the operation of the prior art device. The output voltage waveform of the alternating current power source e is shown in FIG 22 (a). The output voltage waveform of the rectifying device 100 is shown in FIG 22 (b). The inverter 110 essentially operates on the voltage outputted from the rectifying device 100. Here, for example, the high-frequency voltage has a frequency of several dozen kHz. During the peak portion of the timing period when the instantaneous value of the voltage outputted from the rectifying device 100 is higher than a predetermined value and the switching device 112 is on, current is supplied to charge the capacitor 201 via a route consisting of the positive output terminal of the rectifying device 100, the capacitor 201, the current-limiting impedance device 202, the backflow-preventing diode 204, the switching device 112, and the negative output terminal of the rectifying device 100. During the trough portion of the timing period when the instantaneous value of the voltage outputted from the rectifying device 100 is lower than a predetermined value (i.e., during the timing period when the voltage from both terminals of the series circuit consisting of the capacitor 201 of the auxiliary direct current power source 200, the current-limiting impedance device 202 and the isolating diode 203 is higher than the instantaneous value of the voltage outputted from the rectifying device 100), the voltage is supplied to the inverter 110 from the auxiliary direct current power source 200 via a route consisting of the capacitor 201, the parallel resonance circuit 111, the switching device 112, the isolating diode 203 and the current-limiting impedance device 202. The waveform of the voltage supplied to the inverter 110 is shown in FIG 22 (c), and the waveform of the voltage inputted to the rectifying device 100 is shown in FIG 22 (d).

[0005] In this way, the voltage inputted to the inverter 110 is smoothed by filling in the trough portion of the rectified waveform. As a result, the high-frequency output from the inverter 110 does not have a portion of the envelope curve that suddenly drops to zero when rectified pulsating current voltage is supplied. Thus, when the load is a discharge lamp such as a fluorescent lamp, the arc is not extinguished every pulsating current voltage cycle and refired in the next cycle. This improves the light-generating efficiency. The power factor is also improved significantly compared to the simple installation of a smoothing capacitor between the output terminals of the rectifying device.

[0006] One of these power source devices has been proposed in Japanese Unexamined Patent Application Publication No. JP61-46181A. Here, an inductor is installed between the rectifying device and the inverter switching device serving as the high-frequency conversion device, a capacitor is installed for charging using the charge voltage in the inductor, and the inverter switching device is used to create a voltage-raising chopper action.

[0007] This type of power source device is able to supply the output from a capacitor (i.e., relatively constant raised-voltage direct current voltage) to the inverter. The raised-voltage chopper action is able to continuously reduce the high-frequency component in the inputted current.

[0008]

[Problem Solved by the Invention] As described above, the device in FIG 21 is able to supply direct current voltage smoothed by a certain degree to the inverter without reducing the power factor.

[0009] Unfortunately, the waveform of the inputted current is substantially rectangular as shown in FIG 22 (d). This is different from a sine wave and contains a high-frequency component. During the timing period in which power is supplied to the inverter from the auxiliary direct current power source, the current inputted from the alternating current power source is stopped. As a result, the low-distortion inputted current waveform that has become highly desirable in recent years cannot be obtained. When the inputted current is distorted (i.e., contains a high-frequency component), the voltage supplied to the other devices connected to the alternating current power source is also distorted.

[0010] In JP61-46181A, the voltage in the capacitor varies significantly in response to changes in the load. During a low load period when the load is detached, the voltage at both terminals of the capacitor in the non-operating partially raised voltage chopper rises significantly. This can cause a component breakdown such as the failure of a switching device. As a result, components with a very large capacitance have to be used. A protective means has to be used to change the on duty of the switching device so that the voltage at both terminals of the very large capacitance capacitor does not rise. Here, the range for the on duty change has to be increased. This makes the design complicated and reduces design freedom. As a result, the price of the device is higher.

[0011] A purpose of the present invention is to solve the problems associated with prior art devices by providing a power source device with high input efficiency, low input current waveform distortion and very little rise in voltage under a light load that is able to supply smoothed direct current power to an inverter.

[0012] Another purpose of the present invention is to provide a variable output power source device with these functions.

[0013] Another purpose of the present invention is to provide a discharge lamp lighting device with high input efficiency, low input current waveform distortion and very little rise in voltage under no load that is able to supply smoothed direct current power to an inverter.

[0014] Another purpose of the present invention is to provide a lighting device with high input efficiency, low input current waveform distortion and very little rise in voltage under a light load that is able to efficiently light a discharge lamp.

[0015] [Constitution of the Invention]

[0016]

[Means of Solving the Problem] The invention of claim 1 supplies output from a rectifying device used to rectify alternating current voltage to a high-frequency conversion device. An auxiliary direct current power source is installed on the input end of the high-frequency conversion device with an outputted voltage value lower than the peak value of the outputted voltage from the rectifying device, and an inverter is installed in series with the switching device of the high-frequency conversion device between the output terminals of the rectifying device to store power using the current from the rectifying device when the switching device is on. A first capacitor with relatively low capacitance is also installed in parallel with the auxiliary direct current power source to act on the stored energy for the inductor with respect to the high-frequency supplied when the switching device is on.

[0017] In the invention of claim 2, in addition to the characteristics of claim 1, a rectifying element is installed with the same polarity as the output from the rectifying device in at

least one of the output terminals from the rectifying device, and the auxiliary direct current power source and the first capacitor are installed via this rectifying element between the output terminals of the rectifying device.

[0018] In the invention of claim 3, a pair of switching devices is installed in series with the high-frequency conversion device. One of the pair of switching device is installed in series with an inductor. The switching frequency of the pair of switching devices for the high-frequency conversion device is changed to change the output from the high-frequency conversion device. A control means is also installed to make the on period for the switching device installed in series with the inductor longer than the on period for the other switching device when the change in the switching frequency is relatively large.

[0019] In the invention of claim 4, in addition to the characteristics of claim 3, a rectifying element is installed with the same polarity as the output from the rectifying device in at least one of the output terminals from the rectifying device, and the auxiliary direct current power source and the first capacitor are installed via this rectifying element between the output terminals of the rectifying device.

[0020] The invention of claim 5 is the power source device in any one of claims 1 through 4 in which a frequency-rejecting filter is installed between the alternating current power source and the rectifying device.

[0021] The invention of claim 6 is the power source device in any one of claims 1 through 5 in which the auxiliary direct current power source has a charging portion connected via the switching device of the high-frequency conversion device between the terminals of the second capacitor with a relatively large capacitance and the first capacitor including a current-limiting inductor in series for charging the second capacitor with the output from the first capacitor when the switching device is turned on, and a discharging portion connected in series to the second capacitor and installed between the input terminals of the second capacitor and the high-frequency conversion device to form a discharge route for the second capacitor via the high-frequency conversion device.

[0022] The invention of claim 7 is the power source device of claim 6, in which the switching device of the high-frequency conversion device, the current-limiting inductor and the second capacitor constitute a chopper.

[0023] The invention in claim 8 is the power source device in any one of claims 1 through 5 in which the auxiliary direct current power source has a third capacitor with a relatively large capacitance charged by either some of the rectified voltage outputted from the high-frequency conversion device or some of the step-down rectified alternating current power source voltage outputted from the rectifying device, and a discharging portion connected in series to the third capacitor and installed between the input terminals of the third capacitor and the high-frequency conversion device to form a discharge route for the third capacitor via the high-frequency conversion device.

[0024] In the invention of claim 9, a protective means is installed to turn off or reduce the on duty of the switching device in the high-frequency conversion device when a signal corresponding to the voltage value of the auxiliary direct current power supply rises above a predetermined value.

[0025] The invention in claim 10 is a discharge lamp lighting device comprising a discharge lamp and the power source device in any one of claims 1 through 9 for lighting this discharge lamp.

[0026] The invention in claim 11 lights the discharge lamp installed in the lighting device main unit using the discharge lamp lighting device in claim 9.

[0027]

[Operation] In the invention of claim 1, the current flows from the rectifying device via the inductor and the switching device to store power in the inductor when the switching device in the high-frequency conversion device is turned on. When the switching device is turned off, the power stored in the inductor is discharged via a rectifying element installed if necessary as a component of the high-frequency conversion device and the first capacitor to charge the first capacitor. When the switching device is again turned on, current flows from the rectifying device via the inductor and the switching device as described above and the energy is stored in the inductor. At the same time, voltage is supplied from the first capacitor to the high-frequency conversion device via the turned-on switching device. In other words, the voltage from both terminals of the first capacitor has a high-frequency ripple and is the pulsating voltage from the rectifying device that has been raised in voltage somewhat. When the voltage value from the first capacitor has decreased (i.e., when the somewhat raised pulsating outputted voltage is lower than the voltage from the auxiliary direct current power source during the trough portion of the timing period when the instantaneous value of the voltage outputted from the rectifying device is lower), voltage is supplied from the auxiliary direct current power source to the high-frequency conversion device. The storage of power in the inductor and the charging of the first capacitor are repeated as described above during the period in which voltage is supplied from the auxiliary direct current power source to the high-frequency conversion device.

[0028] Because of the operations described above, current flows for nearly the entire rectified voltage cycle, the current inputted from the alternating current continues to have a sinusoidal waveform, and the high-frequency component is very small. The ripple portion corresponding to the switching frequency can also be easily removed using a high-frequency rejection filter common in the art.

[0029] Also, the voltage supplied to the high-frequency conversion device is the voltage from both terminals of the first capacitor in which the trough portion of the rectified pulsating voltage has been filled in. In other words, it is voltage with a ripple that has been superimposed. This voltage converted to high-frequency voltage can be supplied to a load device. Because the voltage is raised somewhat by the low-capacitance first capacitor of the present invention as described above, a constant raised voltage is not generated as in JP61-46181A. As a result, the voltage does not change much when the load changes, and the size of the rise in voltage is relatively small. Therefore, even when a protective means is installed to change the on duty, a relatively simple configuration can be used to reduce the amount of change in the on duty.

[0030] In the invention of claim 2, the auxiliary direct current power source and the first capacitor are installed via a rectifying element installed at the output terminal of the rectifying device. The rectifying element is not affected by the voltage of the auxiliary direct current power source and the first capacitor and the current can flow during most of the rectified voltage cycle. During the peak portion of the timing period when the instantaneous value of the rectified voltage output is high, voltage can be supplied from the rectifying device to the high-frequency conversion device and the auxiliary direct current power source can be charged. The current inputted from the alternating current has a continuous sinusoidal waveform, and the high-frequency component is very small. In these respects, it is similar to the invention of claim 1.

[0031] In the invention of claim 3, the switching frequency of the pair of switching devices is changed by the control means to change the output from the high-frequency conversion device. Because the switching output from the high-frequency conversion device is supplied to an LC series resonance circuit, the output can be changed relative to the resonance frequency of the LC series resonance circuit. If the load circuit has an induction component and a capacitance component connected in series, the output can be changed by changing the impedance value of the inductance component and the capacitance component. However, when the switching frequency is increased, the period of the cycle during which current flows from the rectifying circuit to the switching device is shortened, and there is very little inputted current during the trough portion of the voltage outputted from the rectifying device. In other words, the distortion to the inputted current waveform cannot be reduced as desired. To counter this, the invention of claim 3 makes the on period of the switching device connected in series to the inductor longer than the on period of the other switching device. This can change the switching frequency, extend the period of the cycle during which the current flows from the rectifying device via the inductor and the switching device, and prevent a reduction in the inputted current during the trough portion of the timing period during which voltage is outputted from the rectifying device.

[0032] The invention of claim 4 applies the functions of the invention of claim 2 to the functions of the invention of claim 3.

[0033] The high-frequency rejection filter in the invention of claim 5 effectively keeps the high-frequency ripple portion from being conveyed to the alternating current power source end.

[0034] The invention of claim 6 supplies voltage from the rectifying device to the high-frequency conversion device during the peak period of the outputted voltage and charges the second capacitor of the auxiliary direct current power source via the switching device and the current-limiting inductor when the switching device for the high-frequency conversion device is on if a rectifying element is installed between the output terminal of the rectifying device, the first capacitor and the auxiliary direct current power source as in claim 2 and claim 4. The second capacitor of the auxiliary direct current power source supplies voltage to the high-frequency conversion device via the discharging portion during the trough portion of the voltage outputted from the rectifying device (i.e., when the voltage outputted from the rectifying device is smaller than the voltage at both terminals of the auxiliary direct current power source). Because the invention of claim 6 is configured to use the auxiliary direct current power source as a switching device for the high-frequency conversion device, the number of components can be reduced and the price of the overall device can be lowered.

[0035] The invention of claim 7 stores power in the current-limiting inductor device using the current supplied to the current-limiting inductor via the switching device and supplies this to the auxiliary direct current power source to provide a chopper action. This effectively boosts the power factor and obtains the desired voltage value for the auxiliary direct current power source.

[0036] The invention of claim 8 charges the auxiliary direct current power source using some of the rectified voltage outputted from the high-frequency conversion device, the voltage outputted from the rectifying device or lower-voltage rectified current voltage from the alternating current power source voltage. This makes a charged power source easier to obtain.

[0037] The invention of claim 9 uses a protective means to turn off or reduce the on duty of the switching means when the load is reduced and the voltage value or the discharged current value of the auxiliary direct current power source is raised. In this way, the raised-voltage chopper action is stopped or the rise in voltage is lowered. This can prevent an excessive rise in the voltage value of the auxiliary direct current power source, a breakdown in the switching device for the high-frequency conversion device, and the necessity for a high withstand voltage for the high-frequency conversion device.

[0038] The invention of claim 10 applies the power source in any one of claims 1 through 9 to a discharge lamp. In this way, the voltage supplied to the high-frequency conversion source is smoothed in the manner described above. This provides continuous lighting of a discharge lamp without having to extinguish the arc and refire the lamp every pulsating voltage cycle. This improves the light-generating efficiency.

[0039] The invention of claim 11 provides a lighting device with high light-generating efficiency similar to the invention of claim 10.

[0040]

[Working Examples] The following is an explanation of a working example of the present invention with reference to FIG 1. The components identical to those in FIG 21 are denoted by the same numbers. 1 is a transistor inverter serving as the high-frequency conversion device. It is a series circuit with a parallel resonance circuit 2 and a switching device 3. The inductance component forming the parallel resonance circuit 2 uses a leakage transformer 4 in this working example. The high-frequency conversion device 1 in this working example is a self-exciting device. The primary coil of the current transformer 5 is inserted into the load circuit, and the second coil output is supplied between the base and emitter of the switching device 3.

[0041] The auxiliary direct current power source 6 essentially has a second capacitor 7 with a relatively large capacitance similar to the one in FIG 21, an inductor serving as the current-limiting impedance device 8, the isolating diode 9, and a backflow-preventing diode 10.

[0042] 12 is an inductor in which the switching device 3 of the high-frequency conversion device 1 is installed in series between the output terminals of the rectifying device 100. In this working example, a diode 13 is inserted in series. In the present invention, the other components are inserted either in series or in parallel. For example, the inductor 12 is connected to the rectifying device 100 via a voltage-dividing means. 14 is the first capacitor installed in parallel with the auxiliary direct current power source 6. The first capacitor 14 has a relatively low capacitance to act only on the high-frequency. In other words, it has 1/100th the capacitance of the second capacitor 7 in the auxiliary direct current power source 6.

[0043] 20 is a discharge lamp such as a fluorescent lamp serving as the load. 21 is the capacitor used to start the lamp. In this working example, the leakage inductance from the leakage transformer 4 of the high-frequency conversion device 1 is used as a current-limiting element for the fluorescent lamp 20. However, a separate current-limiting element can also be installed instead of using the choke coil of the leakage transformer 4. The discharge lamp can also be a high-voltage discharge lamp such as a mercury lamp or a cold-cathode fluorescent lamp.

[0044] In this working example, F is a high-frequency rejection filter, 22 is resistance used in the starting process, and 23 is a diode for reverse withstand voltage protection and current feedback.

[0045] The following is an explanation of the operation of this working example. First, during the peak portion of the timing period when the instantaneous value of the voltage (pulsating voltage) outputted from the rectifying device 100 is greater than a predetermined value and the switching device 3 is turned on, current flows from the rectifying device 100 through a route consisting of the inductor 12, the diode 13 and the switching device 3, and energy is stored in the inductor 12. When the switching device 3 is turned off, the power stored in the inductor 12 is discharged via a route consisting of the inductor 12, the diode 13, the parallel resonance circuit 2, the first capacitor 14, the rectifying device 100 and the inductor 12, and the capacitor 14 is charged. In this way, the inductor 12, the first capacitor 14 and the switching device 3 provide a voltage-raising chopper action. When the switching device 3 is turned on again, the charge stored in the capacitor 14 is discharged to the high-frequency conversion device 1, and the capacitor 7 is charged via the second capacitor 7, the inductor 8, the diode 10 and the switching device 3. The charged voltage in the capacitor 7 is set so that the voltage outputted by the constant number setting of the current-limiting impedance device 8 is smaller than the peak value of the voltage outputted from the rectifying device 100.

[0046] Next, during the trough portion of the timing period in which the instantaneous value of the voltage (pulsating voltage) outputted from the rectifying device 100 is lower than a predetermined value, voltage is supplied from the auxiliary direct current power source 6 to the inverter 1. However, when the switching device is turned on as described above, current flows via the route consisting of the inductor 12, the diode 13 and the switching device 3 and the effect is the same as the peak period. As shown in FIG 2 (b), the waveform of the current inputted from the alternating current power source e approximates a sine wave. FIG 2 (a) shows the input voltage waveform, and FIG 2 (c) shows the input voltage waveform (envelope curve) of the inverter 1. As is clear from FIG 2 (c), the inductor 12, the first capacitor 14 and the switching device 3 apply a voltage-raising chopper action during the trough portion of the period. The action of the auxiliary direct current power source 6 smoothes out the voltage inputted to the high-frequency conversion device 1. This improves the light-generating efficiency of the fluorescent lamp 20.

[0047] The following is an explanation of the second working example of the present invention with reference to FIG 3. The components identical to those in FIG 1 are denoted by the same numbers. In this working example, the rectifying element 11 is installed on one of the output terminals of the rectifying device 100, and the auxiliary direct current power source 6 and first capacitor 14 are installed between the output terminals of the rectifying device 100 via the rectifying element 11.

[0048] The following is an explanation of the operation of this working example. During the peak portion of the period in which the instantaneous value of the voltage (pulsating voltage) outputted from the rectifying device 100 is greater than a predetermined value, the high-frequency conversion device 1 is supplied the output from the rectifying device 100 and high-frequency voltage is generated. When the switching device 3 is turned on during this period, current flows via the route consisting of the second capacitor 7, the voltage-limiting inductor 8, the diode 10 and the switching device 3, and the capacitor 7 of the auxiliary direct current power source 6 is charged. When current flows through the passage consisting of the inductor 12, the diode 13 and the switching device 3 and the switching device 3 is turned on, the power stored in the inductor 12 is discharged via the route consisting of the inductor 12, the diode 13, the parallel resonance circuit 2, the first

capacitor 14, the rectifying device 100 and the inductor 12, and the capacitor 14 is charged. The charge in the charged capacitor 14 is discharged when the switching device 3 is turned off.

[0049] The action during the trough portion of the period in which the voltage (pulsating voltage) outputted from the rectifying device 100 is greater than a predetermined value is the same as FIG 1. Therefore, an explanation has been omitted.

[0050] In this working example, the energy stored in the current-limiting impedance device 8 when the switching device 3 is turned on is discharged when the switching element 3 is turned off via the route consisting of the diode 10, the parallel resonance circuit 2, the capacitor 7 and the diode 13. The voltage inputted to the inverter 1 can be set as desired. This configuration can be used in the working examples described below.

[0051] In this working example, the predetermined value used to determine the period in which the auxiliary direct current power source 6 supplies voltage to the inverter 1 is freely selected using a constant number setting for the capacitor 7 and the current-limiting impedance device 8 as explained above.

[0052] The following is an explanation of the third working example of the present invention with reference to FIG 4. The components identical to those in FIG 1 are denoted by the same numbers. In this working example, the inverter 30 is a series-type inverter using a pair of field-effect transistors as the switching devices 31, 32. The inverter 30 itself is an inverter common in the art. In this working example, the auxiliary direct current power source 6 is charged only via one of the switching devices 32. The inductor 12 also receives current from the rectifying device 100 via only one of the switching devices 32. The energy stored in the inductor 12 is discharged to the capacitor 14 via the path consisting of the diode 13, a diode equivalent to the other switching device 31, the capacitor 14 and the rectifying device 100. The rest of the configuration and the action of the working example are easy to understand based on the description above. Therefore, an explanation has been omitted. In this working example, a rectifying element 11 can be installed in the location denoted by the dotted lines. The action of this element is easy to understand. (In regard to this point, the same is true below.)

[0053] FIG 5 shows the fourth working example of the present invention. In contrast to the working example in FIG 4, the inverter 33 does not have a pair of voltage-dividing capacitors. This can use a full-bridge inverter common in the art. Instead of a field-effect transistor, the switching device is a bipolar transistor connected in parallel to the opposite polarity.

[0054] The fifth working example of the present invention is shown in FIG 6. The components identical to those in FIG 4 are denoted by the same numbers. Compared to the working example in FIG 4, the auxiliary direct current power source 6 in this working example is charged only by one of the switching devices 31, and the inductor 12 is also supplied current from the rectifying device 100 only by one of the switching devices 31. The energy stored in the inductor 12 is discharged to the capacitor 14 via the path consisting of the rectifying device 100, the capacitor 14, a diode equivalent to the other switching device 32, and the diode 13. Unlike the working example in FIG 3, this working example does not have a pair of voltage-dividing capacitors. The rest of the actions of this working example can be readily understood based on the description above. Therefore, an explanation has been omitted.

[0055] FIG 7 shows the sixth working example of the present invention in which a parallel inverter with a pair of switching devices 36, 37 is used as the inverter 35. The inverter 35 itself is an inverter common in the art. In this working example, the auxiliary direct current power source 6 is charged only by one of the switching devices 37, and the inductor 12 is also supplied current from the rectifying device 100 only by one of the switching devices 37. In this working example, the voltage generated by the output transformer 38 is the charging power source for the auxiliary direct current power source 6. The charged power in the inductor 12 is used to charge the capacitor 14 via a route consisting of the diode 15, the capacitor 14 and the rectifying device 100. The rest of the configuration and actions are easily understood based on the description above. Therefore, an explanation has been omitted.

[0056] In FIG 8, the auxiliary power source 6' is charged by the output from the high-frequency conversion device 35. In other words, the auxiliary power source 6' in this working example consists of a third capacitor 40 with a relatively large capacitance and an isolating diode 41. The third capacitor 40 is charged using some of the output from the high-frequency conversion device 35. For example, in FIG 8, a coil 38f is installed in the output transformer 38 for feedback. The voltage outputted from the coil 38f is rectified and used to charge the third capacitor 40.

[0057] However, there is no feedback from the other portion of the high-frequency conversion device 35. For example, in FIG 1 and FIG 6, the outputted voltage can be fed back from inductance installed in series with the discharge lamp 20.

[0058] While not shown in the drawing, charging can be performed using voltage from the alternating current power source e that has undergone a voltage reduction and rectification. Charging can also be performed using some of the output from the rectifying device 100.

[0059] FIG 9 shows the eighth working example of the present invention. Unlike the working example in FIG 7, this working example has an auxiliary direct current power source 6' with a pair of current-limiting inductance devices 8', 8', backflow-preventing diodes 10', 10', and inductances 12', 12' corresponding to the switching devices 36, 37 in the high-frequency conversion device 35. Therefore, in this working example, the charge for the auxiliary direct current power source 6' and the current via the inductor 12 arrive via the pair of switching elements 36, 37 in alternating fashion. (The voltage generated by the output transformer 38 is obtained as the charging power source for the auxiliary direct current power source 6' as in FIG 6.) In this working example, the backflow-preventing diodes 10', 10' and the cathodes 13', 13' can be connected at the midpoint between the interim tap t of the output transformer 38 and the various terminals of the input coil.

[0060] In the working examples shown in FIG 7 through FIG 9, a constant-current inductor L is installed on the end with the negative output terminal.

[0061] FIG 10 shows the ninth working example of the present invention. The components identical to those in FIG 1 are denoted by the same numbers. In this working example, when the discharged current value from the auxiliary direct current power source 6 rises and exceeds a predetermined value, the switching device 3 is forcibly turned off or the on duty is reduced by a protective means 62. This protective means 62 can be configured by a person skilled in the art in any way appropriate using a current-voltage converter, comparator and PWM controller.

[0062] In this working example, if a discharge lamp 21 is not attached (light load situation), the chopper action raises the voltage value of the auxiliary direct current power source 6

and the discharge current value increases. In this situation, the protective means 62 forcibly turns off the switching device 3 or reduces the on duty. For example, the switching device 3 is turned off. If there is no protective means 62 and the switching device 3 is turned on and off with the same duty as a normal load despite the fact that there is a light load, the voltage from the auxiliary direct current power source 6 may rise as denoted by E1 in FIG 11. E2 in FIG 11 denotes rectified pulsating voltage. As explained above, this working example can prevent an excessive rise in the voltage value of the auxiliary direct current power source 6, a breakdown in the switching device 3, and the necessity of a high withstand voltage for the switching device 3.

[0063] The protective means 62 can also reduce the on duty of the switching device 3. If the on duty is not reduced, the voltage-raising chopper action continuously raises the voltage of the auxiliary direct current power source 6. Because the on time of the switching device 3 is usually the same, the voltage VCE between the collector and the emitter of the switching device 3 may increase as shown in FIG 12 (a). IC in FIG 12 (a) denotes the collector current for the switching device 3, and FIG 12 (b) shows the normal collector-emitter voltage VCE and collector current IC. As mentioned above, even when the on duty is reduced for the switching device 3, this can prevent a breakdown of the switching device 3, the necessity of a high withstand voltage for the switching device 3, and the continuous output of high voltage.

[0064] A protective means 62' can also be directly applied to the auxiliary direct current power source 6 as shown in FIG 13. Here, the voltage value of the auxiliary direct current power source 6 can be detected by a resistance voltage-dividing circuit. As long as the protective means can turn off the switching device or reduce the on duty, any means devised by a person skilled in the art can be used.

[0065] The output control means prevents output from the inverter. It can change the oscillating frequency of the inverter to reduce or stop the output. Any configuration devised by a person skilled in the art can be used.

[0066] FIG 14 shows the eleventh working example of the present invention. The components identical to those in FIG 1 are denoted by the same numbers. In this working example, the switching frequency of the pair of switching devices 31, 32 can be changed. In other words, the device in FIG 14 has a control means 90 for turning on and off the pair of switching devices 31, 32. By changing the output from this control means 90, the switching frequency can be changed. Because the inverter in this working example has a so-called series resonance circuit containing a series circuit with an inductor 91 and a capacitor 93, the output from the inverter can be changed by changing the switching frequency.

[0067] However, if the switching frequency is raised to reduce the output from the inverter, the on time for the switching devices 31, 32 is shortened. By increasing the switching frequency, the impedance value of the inductor 12 is also increased. Therefore, the current flowing from the rectifying device 100 via the inductor 12 is reduced, and the input current waveform becomes distorted.

[0068] In order to address this, the control means 90 in the working example of FIG 14 simultaneously changes the switching frequency and the on duty of the pair of switching devices 31, 32. In other words, as shown in FIG 15, among the pair of switching devices 31, 32, the on time [FIG 15 (b)] of the switching device 32 related in series to the inductor 12 is lengthened with respect to the on time [FIG 15 (a)] of the other switching device. This can adjust the current flowing from the rectifying device 100 via the inductor 12 to the desired size [FIG 15 (c)] and reduce the distortion of the input current waveform. In FIG 15, (a) is

the drain current of switching device 31, (b) is the drain current of switching device 32, and (c) is the current flowing through the inductor 12.

[0069] If the on duties of the pair of switching devices 31, 32 are not different, the current flowing through the inductor 12 is small as shown in FIG 16, leading to the problems described above. In FIG 16, (a), (b) and (c) denote the same currents as those in FIG 15.

[0070] These control means 90 can be devised by a person skilled in the art using ICs and transmitters able to change the output frequency and on duty in response to an external signal C.

[0071] If the on duties of the switching devices 31, 32 are equal in FIG 14, the input current waveform is shown in FIG 17 (a) and the current from the inductor 12 is shown in FIG 17 (b). If the on duties of the switching devices 31, 32 are changed, the input current waveform is shown in FIG 18 (a) and the current from the inductor 12 is shown in FIG 18 (b).

[0072] If the input to the inverter 33 and the output voltage rise above a predetermined value in FIG 14, turning off the switching device 32 or reducing the on duty has the same effect as a the protective means and output control means described above.

[0073] FIG 19 shows another working example of the present invention. In this working example, an inductor 12' with a variable inductance value is used. If the switching frequency of the pair of switching devices 31, 32 is increased, the inductance value of the inductor 12' can be reduced relative to the increase.

[0074] In other words, the inductor 12' has an interim tap, and a shortable switch 93 is installed between this interim tap and the end to control the switch 93 using the output from controller 90'. The controller 90' differs from the one in FIG 14 in that the switching frequency of the pair of switching devices 31, 32 can be changed but the on duties of the switching elements 31, 32 do not differ from one another.

[0075] In this working example, the switch 93 is turned on by the controller 90' when the switching frequency is increased. This reduces the impedance of the inductor 12' and lowers the input current to prevent distortion of the input current.

[0076] FIG 20 shows a working example of the lighting device of the present invention. 70 is the device main unit. A discharge lighting device 71 of the present invention is installed inside the device main unit. 72, 72 are discharge lamps lit by the discharge lamp lighting device 71. FIG 20 is a working example. The present invention is by no means limited to the device shape or number of lamps shown in this working example. Other variations are clearly conceivable.

[0077] The present invention, in fact, is not limited by any of the aforementioned working examples. Any variation within the scope of the claims is possible. The various characteristics of the working examples can also be combined and exchanged in different ways.

[0078]

[Effect of the Invention] As described above, the invention of claim 1 allows current to flow via the inductance during the period in which voltage is supplied from the auxiliary direct current power source to the high-frequency conversion device. This allows rectifying device

input current to flow continuously during nearly the entire period of the various half-cycles of the alternating current voltage waveform, and the waveform approximates a sine wave. This can smooth the supply of current to the high-frequency current device, improve input efficiency, and reduce the high-frequency component contained in the inputted current. Because the trough portion of the pulsating voltage is filled in, the supplied voltage is smoothed and does not rise in voltage at a constant rate. As a result, the voltage inputted to the high-frequency conversion device does not rise very much during a light load. As a result, the protective means can have a simple configuration.

[0079] The invention of claim 2 is able to charge the auxiliary power source from the rectifying device during the peak portion of the timing period for the voltage outputted from the rectifying device. As a result, the charging means is simple, and the inductor and first capacitor are more compact.

[0080] The invention of claim 3 can change the switching frequency of the pair of switching devices to change the output of the high-frequency conversion device. This can prevent distortion of the inputted current when the switching frequency increases.

[0081] The invention of claim 4 adds the effect of the invention of claim 3 to the effect of the invention of claim 2.

[0082] The invention of claim 5 adds a high-frequency rejection filter to any one of the inventions in claims 1 through 4 to effectively reduce the high-frequency component in the inputted current.

[0083] Because the invention of claim 6 is configured to use the auxiliary direct current power source as a switching device for the high-frequency conversion device, fewer components are required and the price of the overall device is reduced.

[0084] Because the invention of claim 7 stores power in the current-limiting inductor device using the current supplied to the current-limiting inductor and provides a chopper action, power is utilized more efficiently and the voltage from the auxiliary direct current power source can be raised as desired.

[0085] Because the invention of claim 8 uses another means to charge the auxiliary power source, a charged power source is more easily obtained.

[0086] The invention of claim 9 can stop or reduce the rising-voltage chopper action when the load is reduced and the voltage value or the discharge current value from the auxiliary direct current power source rises by using a protective means to forcibly turn off the switching device or reduce the on duty. This can prevent an excessive rise in the voltage value of the auxiliary direct current power source, a breakdown in the switching device for the high-frequency conversion device, and the necessity for a high withstand voltage for the high-frequency conversion device.

[0087] The invention of claim 10 can provide continuous lighting of a discharge lamp without having to extinguish the arc and refire the lamp every pulsating voltage cycle. This improves the light-generating efficiency.

[0088] The invention of claim 11 can provide a lighting device with high light-generating efficiency similar to the invention of claim 10.

[Brief Explanation of the Drawings]

[FIG 1] A circuit drawing of a working example of the present invention.

[FIG 2] A waveform diagram of the voltage and current for the operation of FIG 1.

[FIG 3] A circuit drawing of the second working example of the present invention.

[FIG 4] A circuit drawing of the third working example of the present invention.

[FIG 5] A circuit drawing of the fourth working example of the present invention.

[FIG 6] A circuit drawing of the fifth working example of the present invention.

[FIG 7] A circuit drawing of the sixth working example of the present invention.

[FIG 8] A circuit drawing of the seventh working example of the present invention.

[FIG 9] A circuit drawing of the eighth working example of the present invention.

[FIG 10] A circuit drawing of the ninth working example of the present invention.

[FIG 11] A waveform diagram of the voltage for the operation of FIG 10.

[FIG 12] A voltage circuit diagram in which the time interval has been expanded for the operation of FIG 10.

[FIG 13] A circuit drawing of the tenth working example of the present invention.

[FIG 14] A circuit drawing of the eleventh working example of the present invention.

[FIG 15] A waveform diagram of the current for the operation of FIG 14.

[FIG 16] A current circuit diagram unrelated to FIG 14 for comparison with the operation of FIG 14.

[FIG 17] A current circuit diagram unrelated to FIG 14 for comparison with the operation of FIG 14.

[FIG 18] A waveform diagram of the current for the operation of FIG 14.

[FIG 19] A circuit drawing of the twelfth working example of the present invention.

[FIG 20] A simplified plane view of a lighting device of the present invention.

[FIG 21] A circuit diagram of the prior art.

[FIG 22] A waveform diagram of the voltage and current for the operation of FIG 21.

[Key to the Drawings]

1, 30, 33, 35 ... Inverters, 3, 31, 32, 36, 37 ... Switching Devices, 6, 6' ... Auxiliary Current Power Source, 11 ... Rectification Element, 12,12' ... Inductors, 14 ... First Capacitor, 21, 72 ... Discharge Lamp, 62, 62' ... Protective Means, 70 ... Device Main Unit, 90, 90' ... Control Means, 100 ... Rectifying Device, e ... Alternating Current Power Source, F ... High-Frequency Rejection Filter

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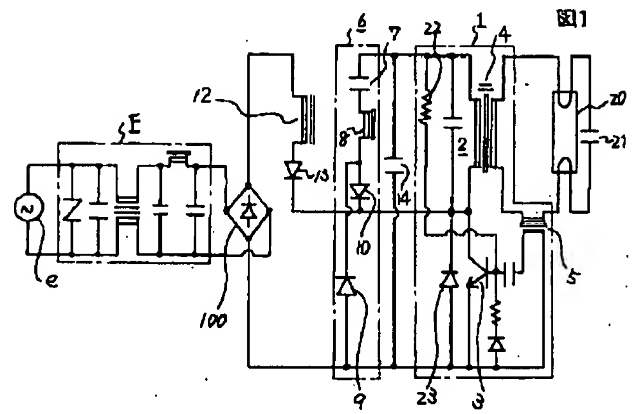
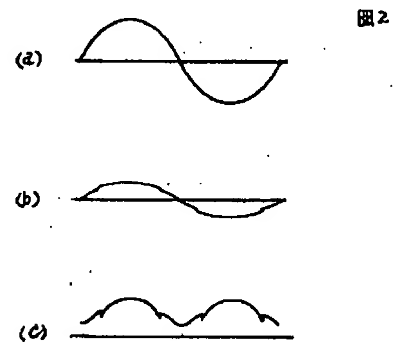
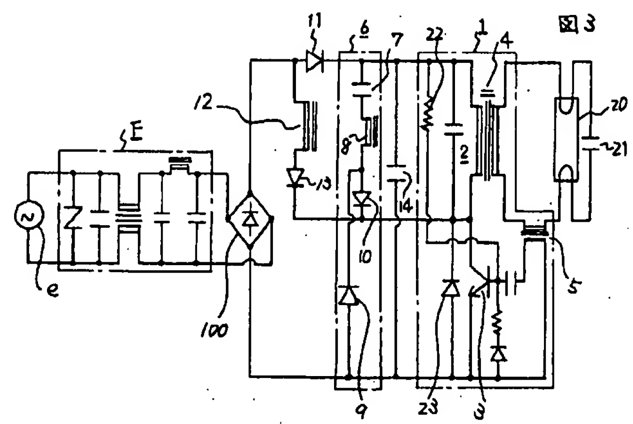
[FIG 1]



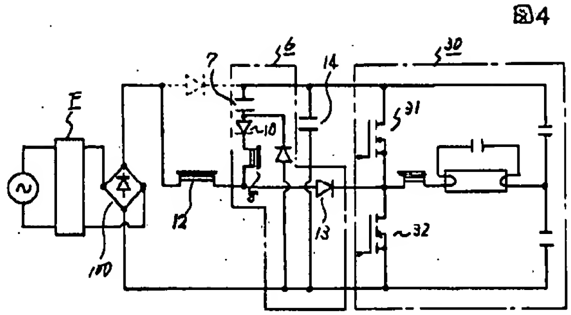
[FIG 2]



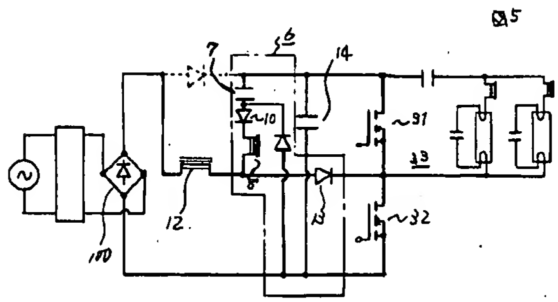
[FIG 3]



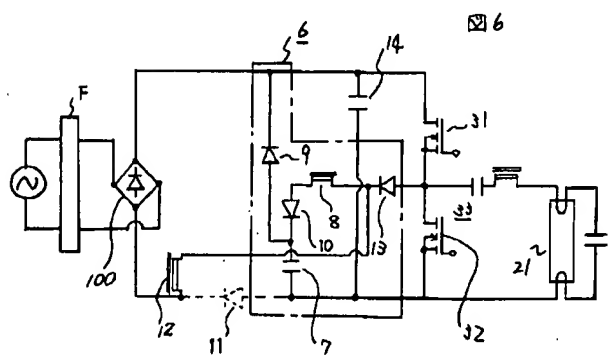
[FIG 4]



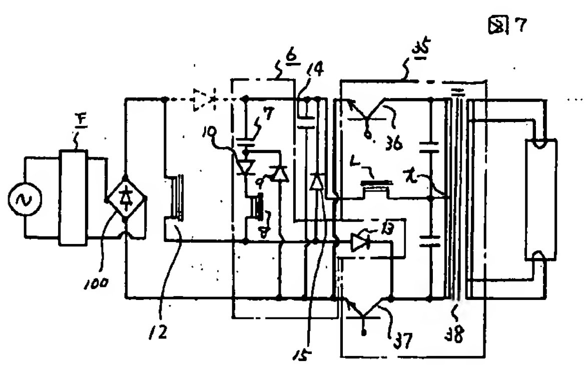
[FIG 5]



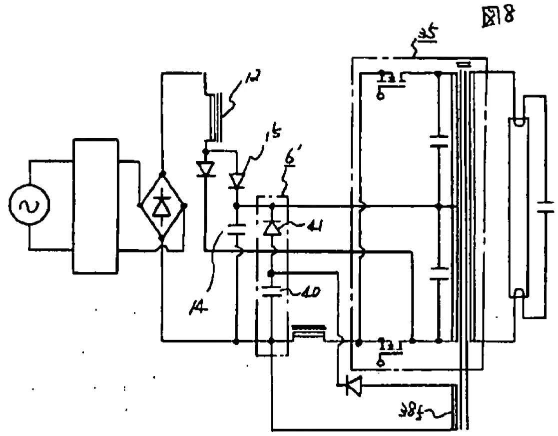
[FIG 6]



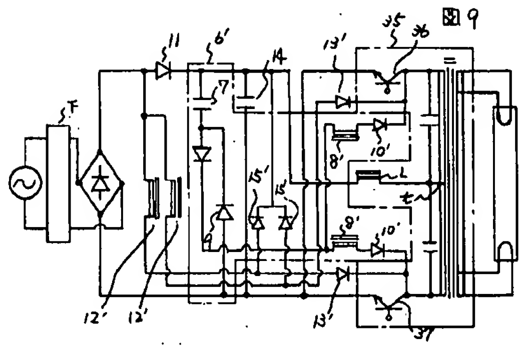
[FIG 7]



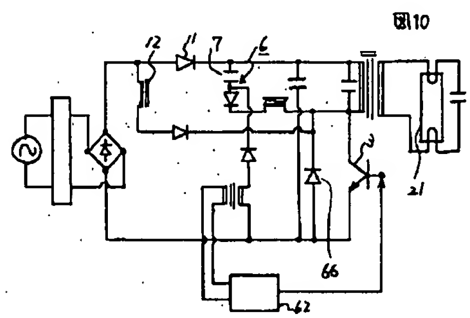
[FIG 8]



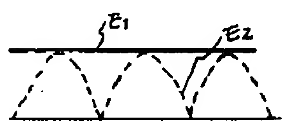
[FIG 9]



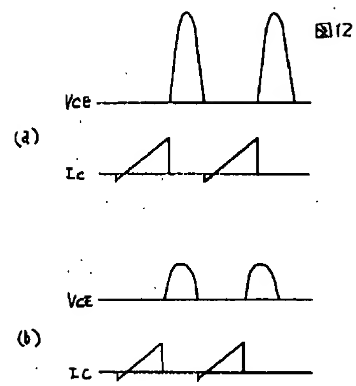
[FIG 10]



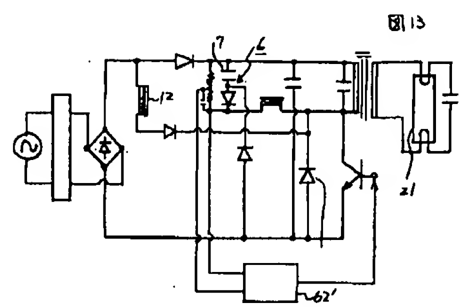
[FIG 11]



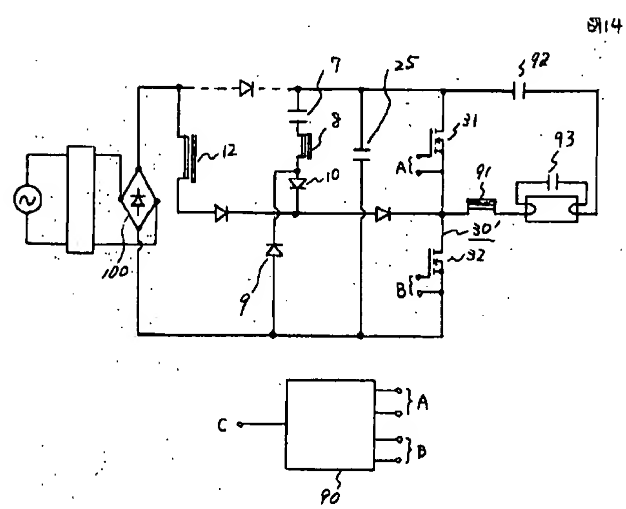
[FIG 12]



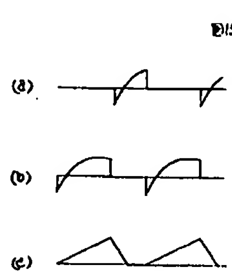
[FIG 13]



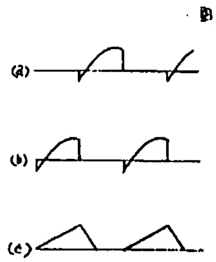
[FIG 14]



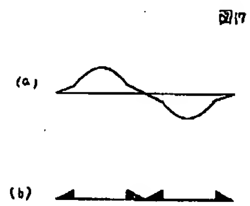
[FIG 15]



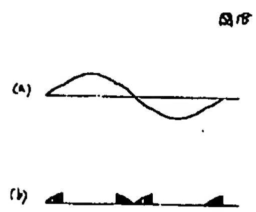
[FIG 16]



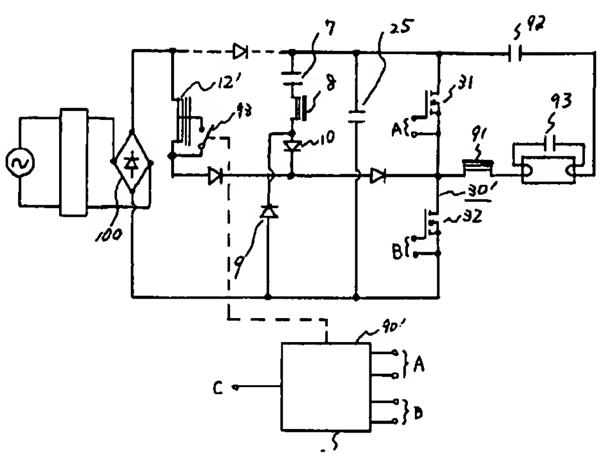
[FIG 17]



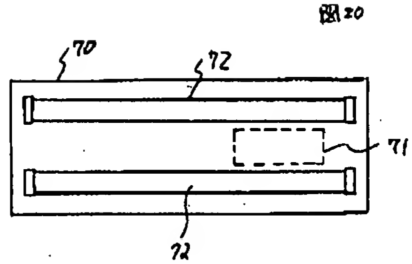
[FIG 18]



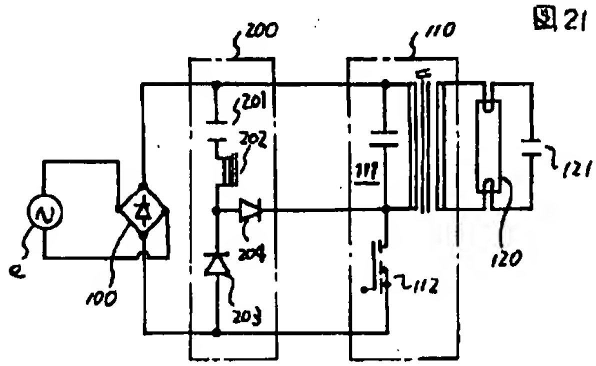
[FIG 19]



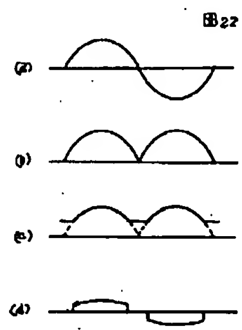
[FIG 20]



[FIG 21]



[FIG 22]



[Amendment of Proceedings]
[Filing Date] June 17, 1993
[Amendment 1]
[Amended Section] Drawings
[Amended Item] FIG 19
[Amendment Method] Revision
[Amendment Details]

[FIG 19]